Studies on the Biology of some Freshwater Fishes

Part I—*Ophicephalus punctatus* Bloch

BY

A. Qayyum

Department of Zoology, Aligarh Muslim University, Aligarh

AND

S. Z. Qasim[1]

Asst. Director, Indian Ocean Physical Oceanography Centre, Ernakulam, Kerala

(*With eight figures*)

General Introduction

It is surprising to note that, although the knowledge of aquatic biology has advanced considerably during the last two decades, very little has been written about the freshwater fishes of India. As compared to marine and estuarine fishes, the work so far done on the biology of freshwater fishes is of a fragmentary nature. Leaving aside the generalisations on the biology of practically every species made by Day (1878), and some studies on the breeding of food fishes in the Punjab and Bengal (Khan 1924, 1942 ; Hora 1945 ; Mookerjee *et al.* 1948), the larval stages and life history of some food fishes (Alikunhi & Rao 1951 ; Alikunhi 1953, 1956 ; Saigal & Motwani 1961), and the age and growth of mrigal, *Cirrhina mrigala* (Jhingran 1957, 1959), other information available is so diffused and scattered that no integrated picture of the biology of any species can be obtained.

Keeping in view the paucity of literature on the subject and the importance of the problem of successful inland fishery management and conservation of fish resources, attempts were made at Aligarh to study the biology of the most common freshwater fishes of this country. The present investigation covers a period of about two years during which time the following three species were investigated :

1. The common murrel, *Ophicephalus punctatus* Bloch
2. The common small barbel (carp), *Barbus stigma* (C. & V.)
3. The common catfish, *Callichrous bimaculatus* (Bloch).

---

[1] Formerly Reader in Fisheries at the University, Aligarh

To maintain the continuity of the present account and to facilitate future publications on other fishes under the same heading, the authors find it best to present the biology of each species as a separate part.

I. *OPHICEPHALUS PUNCTATUS* BLOCH

Introduction

Ophicephalus punctatus Bloch, the common freshwater murrel of India, has an extensive geographical distribution. It is found in Ceylon, Burma, and all over the plains of India (Day 1878). Besides fresh water it has also been recorded from brackish water where it acquires a slightly purple colour (Raj 1916).

O. punctatus forms the mainstay of pond fishery in areas which are far removed from the sea. Being an air-breathing fish fairly large numbers can survive in practically all types of ponds, seasonal or perennial. During the summer months when seasonal ponds get dried, the fish buries itself in the soil and aestivates. Frequently the local fishermen obtain a regular supply of these aestivating fishes by digging one or two feet into the crusted soil. This fish being extremely hardy can be readily obtained in fresh condition, or even alive, at all times of the year. It thus forms a popular item of diet in practically all the states of northern India.

Earlier accounts on this species include comments on eggs and larvae and brief descriptions on nesting and breeding behaviour (Willey 1908 ; Raj 1916 ; Khan 1924 ; Mookerjee 1945 b ; Jones 1946 ; Hosaini & Rahimullah 1946). Recent accounts have dealt with the spawning frequency (Qasim & Qayyum 1961), parental care (Qayyum & Qasim 1962), and fecundity (Qasim & Qayyum 1963). No detailed study has been made on any other aspects of the biology of this fish.

Methods

Samples which formed the basis of the present investigation were collected from ponds in Aligarh by using cast nets at monthly intervals over a period of 19 months, from October 1958 to April 1960. Fishes were measured to the nearest millimetre and grouped at size intervals of 0.5 cm. After wiping off the moisture etc. from the surface of the body, fishes were weighed on a balance sensitive up to 0.1 gm. Gonads from each fish were dissected out, weighed, and assigned a proper stage of maturity. For studying the food, the guts of all fishes were taken out and the contents examined.

TABLE I

NUMBER OF FISH (*O. punctatus*) OF EACH LENGTH GROUP CAUGHT IN VARIOUS MONTHS

Length group	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
cm.												
3.0	30	..	..	..	..	..	..	..	..	..	..	..
3.5	..	10	8	6	..	..	..	..	..	..	..	..
4.0	..	12	11	6	..	..	..	..	..	..	..	..
4.5	..	16	12	8	..	..	..	..	..	..	..	..
5.0	..	14	10	9	..	..	..	..	..	..	..	..
5.5	..	10	10	5	4	..	..	..	..	..	..	..
6.0	..	5	13	6	3	2	1	..	..	..	..	..
6.5	..	7	7	3	6	4	..	..	..	..	..	..
7.0	..	3	16	5	4	4	..	..	..	..	..	..
7.5	..	..	1	1	1	9	11	4	..	..	..	..
8.0	..	..	1	..	3	17	5	3	1	..	..	..
8.5	..	..	2	..	1	17	3	5	3	..	..	..
9.0	..	..	7	8	16	15	7	7	4	..	..	..
9.5	..	..	3	6	39	13	7	7	9	..	..	..
10.0	..	..	1	9	31	18	7	2	5	3	..	..
10.5	..	..	..	4	18	19	5	5	2	2	3	..
11.0	..	1	..	5	26	6	5	4	6	1	..	..
11.5	..	..	1	8	16	1	11	5	8	3	..	..
12.0	..	..	..	6	18	..	2	9	10	7	2	..
12.5	2	1	3	4	5	2	3	4	11	5	1	2
13.0	4	3	2	11	2	3	6	4	10	5	6	4
13.5	6	6	..	6	2	3	..	1	8	7	6	6
14.0	6	7	2	6	2	4	3	2	4	9	3	6
14.5	7	8	2	3	..	3	4	4	5	8	7	7
15.0	9	8	4	3	2	4	2	1	3	5	7	9
15.5	6	9	6	5	2	3	4	1	3	5	5	6
16.0	4	6	6	4	1	2	5	1	3	3	1	4
16.5	3	6	2	3	6	2	4	..	..	2	1	3
17.0	2	4	..	..	1	6	1	2	3	4	2	2
17.5	1	4	4	..	6	4	6	1	1	2	1	..
18.0	1	..	1	3	2	3	3	4	..	1	..	1
18.5	1	1	3	..	2	..	3	..	1	5	..	1
19.0	..	2	1	..	2	2	1	1	1	2	2	1
19.5	2	3	..	2	..	2	2	4	..	1	2	5
20.0	..	6	..	..	..	..	6	1	..	1	2	..
20.5	..	4	..	1	1	..	4	..	..	2	1	
21.0	1	1	1	3	1	1	..	1	..	1	1	..
21.5	2	1	..	1	1	2	..	3	..	..	2	..
22.0	..	1	..	1	..	..	2	..	2	1	2	1
22.5	..	2	..	..	2	..	1	..	1	2	2	..
23.0	2	2	..	..	..	1	..	3	..	..	2	4
23.5	..	4	1	1	..	1	..	..	1	3	..	2
24.0	..	..	1	1	..	..	..	1	1	1	2	..
24.5	..	1	..	2	..	..	..	1	2	..	1	..
25.0	1	..	2	1	..	..	..	1	..	2	..	..
25.5	..	1	1	..	..	..	..	..	2	2	1	..
26.0	2	1	..	..	2	..	..	..	..	..	1	..
26.5	..	..	..	..	1	..	..	2	..	..	1	..
27.0	..	..	..	..	..	..	..	..	..	..	2	..
27.5	1	..	2	..	..	..	..	..	..	..	..	..
28.0	2	..	..	..	..	..	..	..	..	..	..	..
28.5	..	..	..	..	..	..	..	..	..	..	..	..
29.0	..	..	..	..	..	..	..	..	..	..	1	..
29.5	..	..	..	..	1	..	1	..	..	..	..	..
Total	95	170	147	156	230	173	125	94	110	95	70	64

Length frequency distribution

The data pertaining to the length frequency distribution of each month are given in Table 1, after grouping for various duplicate months. Since it was not possible to follow the progression of various modes from month to month, the data for the entire period of observation were pooled in four quarters, each of three months. These are shown as histograms in Fig. 1. The various modes that could be judged by these histograms have been drawn arbitrarily in the figure.

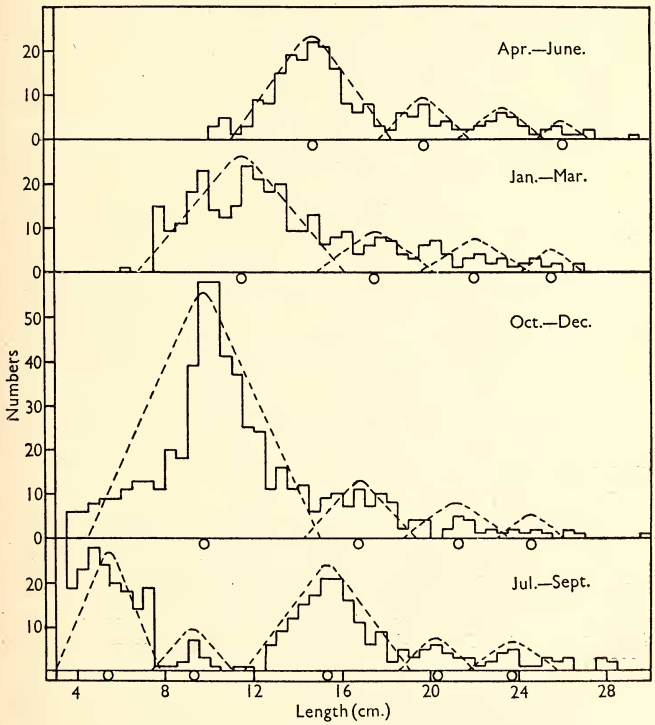

FIG. 1. Length frequency distribution of *O. punctatus*

Open circles indicate average size of each year class as revealed by the modes in the histograms. Possible modes marked arbitrarily by dotted lines.

From Fig. 1 the first three or four year-classes can be clearly demarcated. Size groups below 3.0 cm. in length have not been included in the histograms as these include larval fishes. The breeding season of the fish being June-October, the larvae begin to appear from July and continue to do so till October (Qayyum & Qasim 1962).

The histogram relating to the months of July-September shows modes at four different points : (1) at 5.4 cm., (2) at 15.3 cm., (3) at 20.2 cm., (4) at 23.8 cm. The group represented at 5.4 cm., apparently relates to the brood hatched during June and July (0 group) while the others seem to correspond to older year classes, probably one, two, and three. A small mode following the 0 group fishes at 9.2 cm. seems difficult to interpret. Probably these fishes are one year old and have come from an environment where their growth was slower than usual. This mode though marked in the histogram of July-September could not be followed in other seasons and for this reason it has been excluded from further interpretations.

The histogram for the months October-December also shows four distinct modes. The 0 group which was previously at 5.4 cm. now appears at 9.7 cm. The other groups with their average sizes of 15.3 cm., 20.2 cm., and 23.8 cm. in the previous quarter have shifted to 16.7 cm., 21.2 cm., and 24.5 cm. respectively.

The histogram for the months of January-March can also be demarcated into four modes. The 11.5 cm. group refers to 0 group which has shifted during this period from 9.7 cm. Other groups represented by modes at 17.5 cm., 22.0 cm., and 25.5 cm. in these months belong to first, second, and third year classes.

The histogram for the months of April to June again shows four distinct modes at 14.5 cm., 19.8 cm., 23.2 cm., and 26.0 cm. These indicate that further growth in all the four year classes has occurred in these months also.

The average size of the first four year classes as indicated by the size frequency histograms is given in Table II together with their range in length during each quarterly season. As can be seen from this table the growth is rapid in the first year when the fish reaches approximately 14.5 cm. in length. During subsequent years, it slows down progressively. There appears to be little difference in growth during various seasons.

TABLE II

AVERAGE LENGTH OF VARIOUS YEAR CLASSES OF *O. punctatus* OBTAINED FROM THE LENGTH FREQUENCY DISTRIBUTION OF VARIOUS QUARTERS TOGETHER WITH THE SIZE RANGE OF EACH YEAR CLASS

Year Classes	Months	Range in size	Average length
		cm.	cm.
0	July - Sept.	3.0 - 7.8	5.4
	Oct. - Dec.	4.5 - 15.0	9.7
	Jan. - March	6.8 - 16.1	11.5
	Apr. - June	11.2 - 18.3	14.5
1	July - Sept.	11.5 - 19.0	15.3
	Oct. - Dec.	14.2 - 19.2	16.7
	Jan. - March	14.9 - 20.1	17.5
	Apr. - June	17.8 - 21.8	19.8
2	July - Sept.	18.5 - 22.0	20.2
	Oct. - Dec.	18.8 - 23.4	21.2
	Jan. - March	19.6 - 24.6	22.0
	Apr. - June	21.3 - 25.1	23.2
3	July - Sept.	21.8 - 25.8	23.8
	Oct. - Dec.	23.0 - 26.1	24.5
	Jan. - March	24.1 - 27.0	25.5
	Apr. - June	24.8 - 27.1	26.0

BREEDING

(*a*) *Stages of Maturity*

More or less similar to the scheme given for *Blennius pholis* L. and *Centronotus gunnellus* (L.) (Qasim 1957 a & b), five stages of maturity were drawn on the basis of the general appearance of gonads as follows :

	FEMALES	MALES
Stage I		
	Immature virgins	*Immature virgins*
	Ovaries very small, translucent, measuring 0.7 to 1.8 cm. in length. Elongated and cylindrical, rather oblong in shape. Light red in colour. Eggs microscopic. Gonad weight 0.008 to 0.058 gm.	Testes pinkish and translucent, very small, 0.3 to 0.5 cm. in length. Gonad weight 0.001 to 0.005 gm.

	Females—(*Continued*)	Males—(*Continued*)
Stage II	*Maturing virgins or recovered spents*	*Maturing virgins or recovered spents*
	Ovaries slightly enlarged occupying more than one-third of the body cavity. Flesh-coloured. Gonad weight 0.002 to 0.402 gm.	Testes pinkish and opaque, still small, slightly distended. Gonad weight 0.003 to 0.082. gm.
Stage III	*Ripening*	*Ripening*
	Ovaries enlarged and occupying more than half of the body cavity, pinkish yellow in colour. Two groups of eggs visible to the naked eye. Gonad weight 0.092 to 1.850 gm.	Testes flesh-coloured, opaque, distended in girth. Gonad weight 0.008 to 0.098 gm.
Stage IV	*Ripe*	*Ripe*
	Ovaries very much enlarged, occupying the whole of the body cavity. Yellow in colour, eggs rounded, large, yellow and opaque. Gonad weight 1.23 to 16.8 gm.	Testes dull pinkish. Distended in girth. Gonad weight 0.009 to 0.112 gm.
Stage V	*Spent*	*Spent*
	Ovaries flesh-coloured, flaccid, and shrunken, with some residual eggs. Gonad weight 0.047 to 1.10 gm.	Testes shrunken and dull reddish. Gonad weight 0.003 to 0.065 gm.

(*b*) *Size at First Maturity*

To determine the minimum size at first maturity total numbers of each sex at various maturity stages were tabulated. These are given in Table III. It can be seen from the table that in both sexes, individuals measuring from 5 to 10 cm. in length belong to the immature virgin class (Stage I). Fishes larger than 10 cm. show the next higher stage of maturity (Stage II). In 11 and 12 cm. size groups all the five maturity stages are found. The smallest ripe fishes (Stage IV) in both sexes were recorded in 11 cm. group and these were mostly found in July and August as they mature for the first time and spawn late during the breeding season. Their maximum ripeness in these months is in contrast to older age groups which show peak maturity in May and June. It can thus be concluded that both sexes mature when they are about 11 cm. in length and spawn for the first time when they are about one year old.

Table III

Maturity stages of *O. punctatus* in various length groups

Maturity Stages		Length in cm.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
	Male	I.	33	28	33	38	74	75	20	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		II.	..	..	..	..	..	..	30	42	38	22	16	10	14	7	10	7	12	4	6	5	2	4	1	..	2
		III.	..	..	..	..	..	..	1	2	11	15	13	4	4	2	..	5	2	2	1	2	5	1	..	..	..
		IV.	..	..	..	..	..	..	2	2	5	12	13	10	8	5	7	5	1	3	10	3	5	3	3	2	1
		V.	..	..	..	..	..	..	5	..	..	4	13	6	6	5	1	6	2	2	4	3	2	2	1	..	..
	Female	I.	29	29	26	23	74	59	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		II.	..	..	..	..	..	..	36	40	27	14	16	21	12	9	8	5	3	4	1	1	..	..	..	..	..
		III.	..	..	..	..	..	..	1	2	11	11	6	..	5	2	4	..	1	3	2	..	..	..	..	..	..
		IV.	..	..	..	..	..	..	4	1	10	25	21	12	5	5	8	1	..	1	..	..	..	..	..	..	..
		V.	..	..	..	..	..	..	1	1	9	9	14	9	3	1	..	..	2	1	3	..	..	..	..	..	..

(c) *Sex Ratio*

Out of 1410 fishes which were sexed during the entire period of observation, 772 were males and 638 were females (Table IV). This shows that in the population, males are in the majority. The largest male obtained was of 29.7 cm., whereas the size of the largest female was 24.3 cm. Fishes larger than 24.3 cm. were all males in the sample. Probably the males have either a faster growth rate or they have a greater longevity.

TABLE IV

NUMBER OF FISH (*O. punctatus*) AT EACH OF THE FIVE MATURITY STAGES IN EACH MONTH

Month	Sex	Maturity Stages					Total
		I	II	III	IV	V	
October	Male	12	10	..	..	11	33
	Female	7	6	..	..	10	23
November	Male	65	32	..	..	..	97
	Female	44	18	..	..	..	62
December	Male	27	16	..	..	..	43
	Female	26	15	..	..	..	41
January	Male	22	21	..	..	..	43
	Female	18	11	..	..	..	29
February	Male	9	12	..	..	..	21
	Female	7	12	..	..	..	19
March	Male	9	18	5	..	..	32
	Female	7	14	3	..	..	24
April	Male	2	8	15	1	..	26
	Female	..	7	9	1	..	17
May	Male	2	4	10	19	..	35
	Female	..	5	11	19	..	35
June	Male	..	2	7	23	..	32
	Female	..	2	6	24	..	32
July	Male	..	2	6	20	8	36
	Female	..	..	3	20	6	29
August	Male	21	..	3	27	22	73
	Female	18	..	3	20	18	59
September	Male	31	2	..	9	16	58
	Female	39	6	..	..	13	58
October	Male	28	7	..	..	9	44
	Female	21	9	..	..	6	36
November	Male	23	16	..	..	..	39
	Female	16	16	..	..	..	32
December	Male	25	22	..	..	..	47
	Female	19	23	..	..	..	42
January	Male	11	18	..	..	..	29
	Female	9	15	..	..	..	24
February	Male	8	18	..	..	..	26
	Female	8	20	..	..	..	28
March	Male	5	14	7	..	..	26
	Female	6	16	6	..	..	28
April	Male	4	10	17	1	..	32
	Female	2	2	7	9	..	20
Total	Male	304	232	70	100	66	772
	Female	247	197	48	93	53	638

(d) Spawning Cycle

In both sexes the various stages of maturity obtained in each month are given in Table IV and shown in Fig. 2. As can be seen from the figure, from September onwards the population mainly includes maturing fishes or recovered spents. No further advance over this maturity stage is seen until February. In March ripening stage begins to appear and in April this stage becomes predominant. In May and June both sexes reach peak ripeness (Stage IV) and from July onwards as the fish begin to spawn both ripening and ripe stages continue to occur until September. Though spent fishes start appearing in late July their main proportion in the population is not seen until August and September. The presence of large number of ripe fishes from May to September indicates that the breeding season lasts from June to October. As has been shown elsewhere (Qasim & Qayyum 1961), the ripe ovaries of every female contain more than one group of ova and thus there is every likelihood that each individual may spawn more than once during the breeding season. The continued occurrence of ripening stage as a predominant feature in breeding months strongly suggests that such an overlap in the cycle may be due to repeated spawnings of each individual.

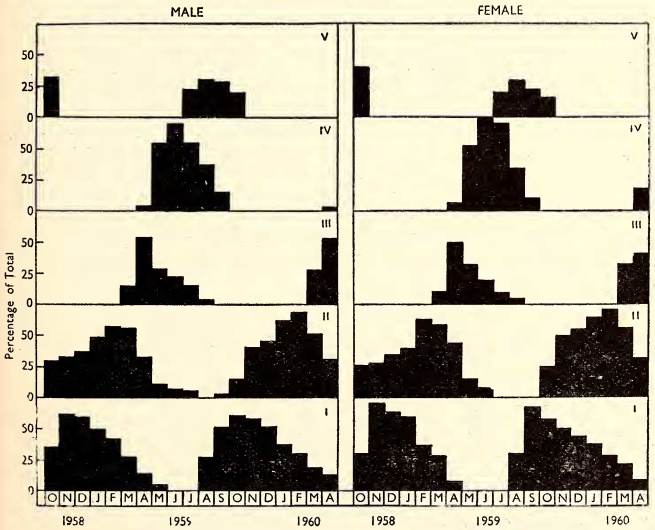

FIG. 2. Percentage of *O. punctatus* at each of the five stages of maturity in different months

(e) Seasonal Changes in Gonad Weight

Fig. 3 shows the seasonal changes in the gonad weight of both sexes. The data referring to the weight of gonads in each month have been expressed as a percentage of body weight. It can be seen from the figure that the curves for males and females follow almost the same pattern but for the fact that seasonal changes in the weight of testes are very slight.

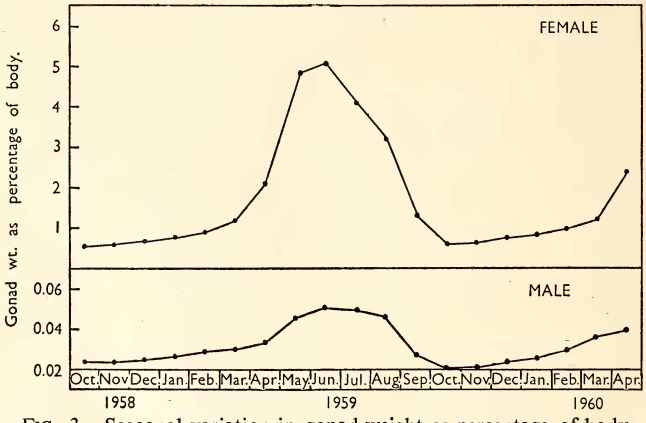

FIG. 3. Seasonal variation in gonad weight as percentage of body weight of *O. punctatus*

The testes remain in a resting condition till January and show no noticeable change in their weight. From March onwards they begin to increase in weight which reaches its maximum in June. After June there is a slow decline and the minimum gonad weight is recorded in October. This gradual decline suggests that the males also remain ripe over a long period and, like the females, do not become spent after the early spawnings.

The ovaries gain considerable weight in pre-spawning months and reach their peak condition in June. From July they register a fall in their weight which continues till October.

The cycle of gonad weight clearly indicates the spawning season of this fish. Maximum values obtained in both sexes during July signify peak maturity in that month. Its fall during subsequent months which is associated in all probability with spawning provides further evidence that the spawning season of the fish lasts from June to October.

(f) Occurrence of Larvae

The larvae of this fish guarded by both parents are of common occurrence in shallow areas of ponds (Qayyum & Qasim 1962). The first

batch of larvae was seen on 2 July and the last batch on 23 October. In the former batch the larvae on an average measured 1.5 cm. whereas in the latter they were 2.5-2.8 cm. in length. From the size of the larvae of the first batch it can be inferred that they must be about 8-10 days old. The fish, therefore, begins to spawn in the last fortnight of June. That the spawning season lasts till October becomes evident from the fact that the last batch of larvae which measured 2.5-2.8 cm. in length must be about three weeks old.

In *O. punctatus* several earlier authors have observed the occurrence of larvae at different times of the year. In Bengal its breeding season seems to last from June to August (Mookerjee 1945 b). In Ceylon, Willey (1908) reported newly hatched larvae in April and May. According to Raj (1916) at Madras, *O. punctatus* breeds twice in a year—first in January and February and again in July and August. Jones (1946) has seen a number of broods in August and September at Madras, while Hosaini & Rahimullah (1946) concluded that *O. punctatus* breeds throughout the year in Hyderabad. From these accounts it appears that this fish may have two breeding seasons in south India corresponding to two monsoons. In northern India it has only one breeding season which lasts from June to October.

(*g*) *Spawning Periodicity*

Studies on the size frequency distribution of oocytes have indicated that the ovaries of *O. punctatus* contain two well defined groups of maturing ova (Qasim & Qayyum 1961). This raised the possibility that like *B. pholis* (Qasim 1956a, 1956b) this fish may also have a succession of spawnings during the breeding season. To confirm this, an aquarium study was arranged but every effort to persuade the fish to breed in captivity remained fruitless. Further evidence of such breeding behaviour was obtained by studying the spawning periodicity of the fish as based on ova-diameter measurements.

During the breeding season, ovaries from several specimens were fixed in 10% formalin at fortnightly intervals. A small portion of the ovary from the middle region was then taken and all the eggs contained in it were separated and measured under a micrometer eye-piece. Usually 500-1000 maturing eggs were measured from each fish. In making measurements, the oocytes smaller than 0.2 mm. were not considered as they occurred throughout the year.

On plotting the percentage frequency of all the measured eggs from each fish it appeared that there was a great deal of individual variation in the same month, particularly after the spawning season began. Typical conditions were, however, laid down on the basis of their relative predominance in various months. These are shown in Fig. 4.

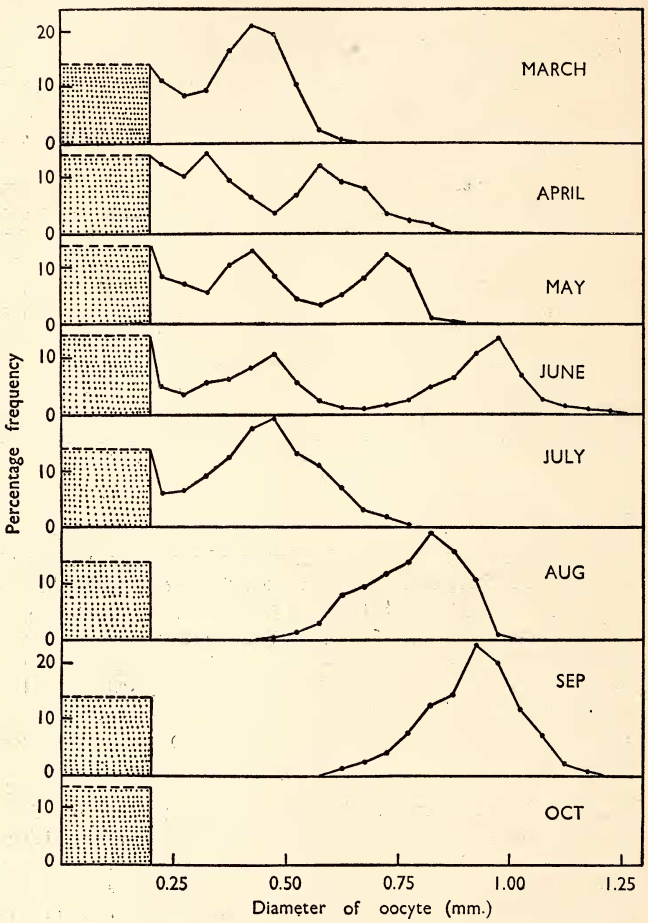

FIG. 4. Size frequency distribution of intra-ovarian eggs of *O. punctatus* from March to October

Stippled areas show small, immature eggs which were not measured.

In March when most fishes reach maturing stage (Stage II), the gonads show only one batch of eggs with a peak at 0.45 mm.—the maximum size of eggs being 0.65 mm. In April the size of eggs increases markedly

and there are two distinct batches, one of ripening eggs with a peak at 0.55 mm. and the other which includes immature eggs has an average size of 0.30 mm. In May these two batches become well defined. Most fishes in this month attain the ripening stage (Stage III). In June when the fishes are mostly ripe (Stage IV) these two groups become widely separated. The larger eggs attain an average diameter of 0.95 mm., whereas the immature eggs have an average size of 0.45 mm. The condition shown in Fig. 4 for July was obtained from parent females which were captured while exhibiting brood care. In most of the parent females the condition revealed by the ovaries was similar to that shown for July. In August there was again a considerable overlap in the ova-diameter frequencies as the ovaries of the late spawners which mainly include juvenile fishes show more or less condition depicted for May or June. These fishes which are maturing for the first time have two groups of eggs. However, in August many large-sized females had only one group of eggs as shown in Fig. 4. These eggs attain a maximum size of 0.95 mm. with its peak at 0.8 mm. In September, as the only group of eggs present in the ovaries becomes fully mature, the peak shifts to 0.9 mm. and the maximum size of eggs reaches 1.2 mm. In October when the fishes are completely spent (Stage V) the ovaries contain very small oocytes measuring less than 0.25 mm. In this month also the juveniles have an exception of having another group of small eggs present. Presumably in these fishes the second group of eggs is retained in the ovaries and is finally resorbed during subsequent months.

Thus by following the growth of both batches of eggs during the breeding season it becomes clear that at least in large-sized females of the population, both groups of ova are matured and shed in succession during the same breeding season.

(*h*) *Condition Factor*

The coefficient of condition or ponderal index forms an important part of fishery research and it has often been used to provide additional information about spawning, feeding, and other aspects related to the well-being of fish (Le Cren 1951). In the present investigation the condition factor of each fish was calculated by the formula suggested by Hile (1936):

$$K = \frac{W \times 100}{L^3},$$

where W=weight in gm., L=length in cm., and K=condition factor.

The figures obtained from each fish throughout the period of observation were pooled in two ways to find the arithmetical means of each size group and of each month. These have been plotted in Figs. 5 and 6.

As can be seen from Fig. 5, in both sexes the K values increase steadily

up to 19 cm. in length. Thereafter, the values begin to fall and reach their minimum at a length of 24 cm. in females and at 29.5 cm. in males.

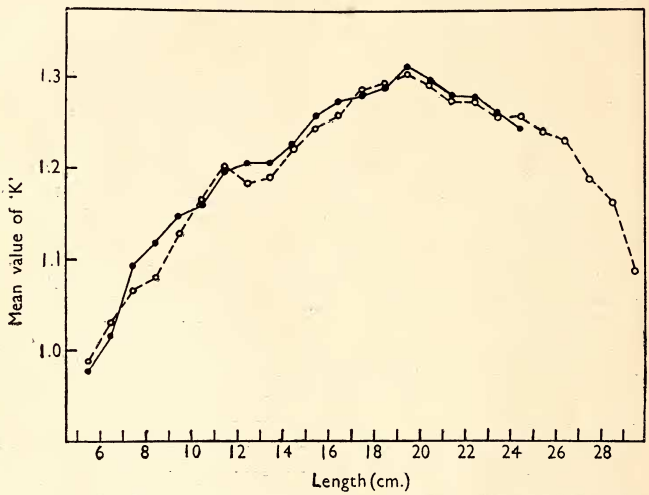

FIG. 5. Mean condition factor (K) of *O. punctatus* at different lengths

Of females, continuous line ; of males, broken line

Hart (1946) pointed out that, since the adolescent fishes have higher K values than the older fishes, the increase and decrease in the K values related to the increasing length can be employed to determine the size at first maturity. This feature has often been applied successfully in many forms (Menon 1950 ; Pillay 1954 ; Sarojini 1957).

In the present case as can be seen from Fig. 5, the actual point of inflection in the curve which is at 19 cm. does not correspond to the size at first maturity as has been established by a more direct evidence. However, at 11 cm. there is a tendency in the curve to change slope. This feature is more marked in males than in females. One may regard this point as that corresponding to the point of inflection, which agrees well with the size determined by an observation of the seasonal changes in the gonad condition. The secondary fall in the condition factor noticed in larger fishes of both sexes, starting from 19 cm. (Fig. 5), is probably because of increasing metabolic strain due to spawning in older age groups. Perhaps with increase in age senility sets in and complete recovery which contributes towards reserve building and increase in weight gradually

declines. Presumably this is the reason of their being poorer in condition factor than the younger breeders.

Several factors have been pointed out by earlier investigators to affect the condition of fishes. Fluctuation in the gonad weight is the main factor which seems to regulate the condition factor (Le Cren 1951 ; Morrow 1951). The other factor which seems to govern the rise and fall of K values is the feeding rate of fish (Qasim 1957a ; Bal & Jones 1960).

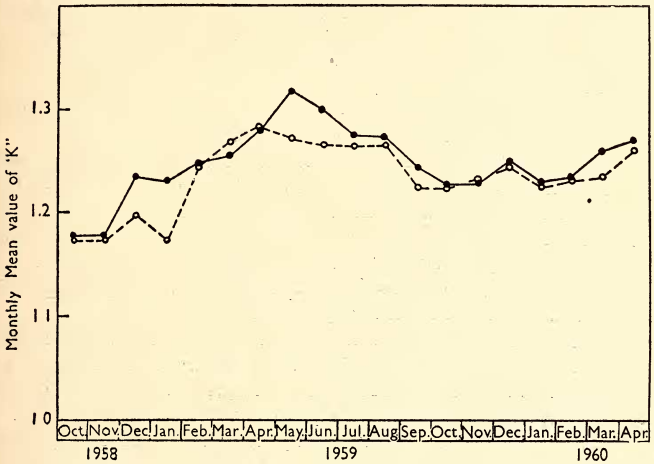

FIG. 6. Seasonal changes in the condition factor (K) of *O. punctatus*
Of females, continuous line; of males, broken line

The seasonal variation in the condition factor has been illustrated in Fig. 6. In calculating the mean for each month, the K values of immature fishes were neglected and the data related to each month refer to the adolescent and older age groups only. As Fig. 6 will indicate, in females the condition factor is lowest in October and November. In December it increases rapidly and reaches its maximum in May. From June onwards it records a steady fall which continues till October. In males except for the lowest value which is obtained in January, the condition factor follows fluctuations similar to those shown by the females. Maximum values in both sexes coincide with the time when gonads reach peak maturity. Their consistent decline from June to October may be attributed to spawning. The time of the poorest condition factor (October and November) is probably due to complete loss of reserve, for both sexes remain busy in brood care until October. From December onwards the rise and fall in the condition factor seem entirely related to the cycle of feeding. A secondary rise in December is probably due to

general building up of body reserves as the intensity of feeding in preceding months is relatively high (see page 98).

Food and Feeding Habits

Little is known about the food and feeding habits of this fish. Brief references have been made earlier which indicate that *O. punctatus* is carnivorous, its food consisting of insects, crustaceans, and fishes (Alikunhi & Rao 1947 ; Mookerjee *et al.* 1946a). Its larvae have been noted to feed on unicellular algae and protozoans (Mookerjee *et al.* 1946b).

A detailed study which includes qualitative and quantitative analysis of food was made on the basis of gut contents as follows :

Guts of all the fishes collected in each month were dissected out and the contents of each were carefully removed in petri-dishes containing water and examined under a dissecting microscope. Each item of food contained in the gut was listed and expressed as a percentage of the total number of guts examined which contained food in that month. In other words the method of the analysis of food was the frequency occurrence method (see Hartley 1947 ; Qasim 1957a, 1957b).

Practically all samples used for the present investigation were collected during the forenoon, from 7.00 a.m. to 12 noon. It can therefore be presumed that the food of all samples was subjected to the same amount of digestion and that any diurnal rhythm in feeding was also avoided.

As there were differences in the food preferences of various size groups, it was considered necessary to maintain a separate record of each fish. Later on the fishes were grouped into the following three heads and the food of each group was analysed separately :

1. Adolescent and older fishes,
2. Immature fishes,
3. Larvae.

(*a*) *Food of adolescent and older fishes*

This group includes fishes from 10 cm. to 29.7 cm. in length. In all, 1047 fishes of this size range were examined. Of this, 895 were found to contain food. Table V shows the percentage occurrence of different items of food during the entire period of observation. It can be seen from the Table that *O. punctatus* is predatory in habit and that other forage fishes form its main food. Besides these, the fish also consumes insects, gastropods, prawns, and algae. Fig. 7(A) shows the frequency of occurrence of various categories of food. In this figure the various food items given in Table V have been grouped into four main heads: (a) fish, (b) insects, (c) crustaceans, and (d) miscellaneous organisms.

TABLE V

PERCENTAGE OCCURRENCE OF VARIOUS CATEGORIES OF FOOD IN THE GUTS OF ADOLESCENT AND OLDER FISHES (*O. punctatus*)

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
No. of fish examined	50	122	39	45	26	45	43	70	64	65	93	46	29	39	73	50	46	50	52
No. of fish with food	43	102	33	38	23	42	41	62	51	49	71	39	25	34	61	46	40	46	49
Barbus stigma	72.1	77.4	57.6	42.1	34.8	47.6	68.3	56.4	45.1	36.7	47.9	53.8	84.0	67.6	44.3	47.8	45.0	58.7	61.2
Esomus danricus	18.6	27.4	15.1	15.8	26.1	28.7	9.7	17.7	11.8	14.3	4.2	20.5	..	26.5	8.2	6.5	10.0	17.4	14.3
Trichogaster chuna	..	..	..	2.6	..	..	2.4	..	..	..	2.8	..	..	..	..	..	..	..	..
Mystus sp.	..	..	3.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ophicephalus punctatus	..	1.0	..	..	4.3	2.4	..	..	..	..	1.4	..	..	..	..	..	..	..	..
Amblypharyngodon mola	..	..	..	..	..	..	..	..	..	..	1.4	..	..	..	..	..	..	..	..
Callichrous pabda	..	..	..	..	..	..	..	..	..	..	1.4	..	..	..	..	..	..	..	..
Digested fish	4.6	7.8	3.0	5.3	8.7	9·5	7.3	1.6	15.7	26.5	11.3	15.4	4.0	5.9	16.4	4.3	7.5	10.7	4.1
Hemiptera	6.9	15.7	12.1	15.8	17.4	23.8	31.7	14.7	15.7	10.2	8.4	5.1	12.0	11.8	18.0	13.1	12.5	2.8	4.1
Odonata	..	2.0	9.1	18.4	26.1	9.5	2.4	..	2.0	..	..	..	4.0	..	11.5	17.4	15.0	6.5	..
Coleoptera	2.3	..	6.1	10.5	17.4	11.9	4.9	4.9	5.9	8.2	2.8	..	..	2.9	3.3	6.5	2.5	..	..
Diptera	..	..	3.0	..	4.3	7.1	2.4	..	3.9	..	..	..	..	..	6.5	6.5	12.5	8.7	14.3
Digested insect	2.3	..	6.1	7.9	13.0	11.9	19.5	9.8	13.7	16.3	4.2	12.8	..	2·9	6.5	2.2	10.0	13.0	10.2
Gastropod	11.6	5.8	9.1	10.5	4.3	2.4	..	1.6	..	10.2	14.1	5.1	8.0	8.8	6.5	15.2	5.0	..	2.0
Prawn	2.3	2.0	..	2.6	..	..	2.4	..	..	..	2.8	2.6	..	..	1.6	..	..	..	..
Algae	..	..	..	2.6	4.3	4.8	..	..	..	..	..	..	..	..	..	..	..	..	..
Higher aquatic plants	..	..	3.0	..	..	..	..	..	..	2.0	1.4	..	..	..	..	..	..	..	..
Water spider	2.3	2.0	..	..	..	..	..	1.6	..	..	..	..	..	..	..	..	..	..	..
Frog	..	1.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

As can be seen from the figure, fish form the dominant food throughout the year. During the pre-monsoon (March-June) and post-monsoon months (Oct.-Nov.), the occurrence of fish in the guts is relatively higher. This is probably due to the fact that during the pre-monsoon months, when the quantity of water in ponds has considerably receded, the fish

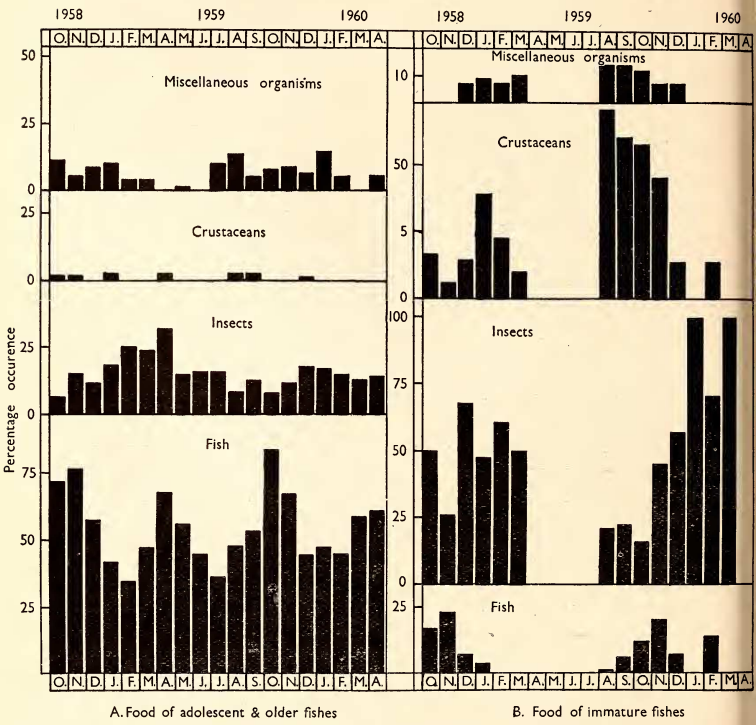

FIG. 7. Histograms showing the percentage occurrence of principal items of food of *O. punctatus* in different months

gets a better chance of catching other small fishes. In the post-monsoon months, soon after the breeding season of other fishes is over, small metamorphosed fishes belonging to the current year's brood become abundantly available in ponds. In these months the guts of *O. punctatus* largely contained small fishes.

In all, seven species of fish were found in the guts (Table V). Of these, *Barbus stigma* was predominant and occurred in all the months of

the year. It constituted 68.5% of the total fish food. Frequently the guts contained no other food except *B. stigma*.

Esomus danricus was the other fish ingested. It occurred in almost all the months of the year. The maximum number (28.7%) of the guts containing this fish was obtained in March 1959.

Other fishes *Trichogaster chuna*, *Amblypharyngodon mola*, *Mystus tengara*, and *Callichrous pabda* occurred rarely in the guts. There were four instances when smaller *O. punctatus* were recorded in the guts of larger fishes. Such fishes contained nothing else but *O. punctatus*, suggesting that cannibalism in this species is rare and possibly occurs when no other food is available. Parents, however, have never been found to contain any young ones of their own kind in their guts (Qayyum & Qasim 1962).

Digested fish remains in the gut were of common occurrence throughout the period of observation. These were difficult to identify and sometimes included scales, bones, and other fish remains.

Insects formed the next important item of food. Practically all the insects found in the guts were aquatic species. Hemiptera, Odonata, Diptera, and Coleoptera constituted the main groups of insects. In pre-monsoon months (March-June), the frequency of occurrence of insects was the highest.

From the hemipterous group, water bugs (*Corixa*, *Notonecta*, *Garris*, and *Nepa* spp.) were the commonest organisms. Of these, the former two occurred all the year round and showed little fluctuations whereas the latter two were rather rare. The maximum number of guts containing these insects was in April 1959.

Nymphs of dragon fly (Odonata) were also of frequent occurrence in the guts. During winter months (December-February), the percentage occurrence of nymphs was relatively higher.

Other insects present in the gut were beetles (Dytiscidae) and fly larvae and pupae (chironomid). Beetles were not very frequent and their numbers in the gut were also few. Chironomid larvae, on the other hand, were abundantly found in the pre-monsoon months. They mostly occurred in smaller fishes and were seldom present in fishes larger than 15 cm. Mosquito-larvae were recorded only from two guts.

Gastropod shells were of consistent occurrence in the gut. During the entire period of investigation, three months were the only exceptions when they were not recorded (Table V). Seven fishes contained prawns and three contained water spiders.

Algae and leaves of higher aquatic plants were rarely eaten. Filamentous algae (*Spirogyra* and *Oscillatoria*) were negligible in proportion and seem to be ingested along with other food organisms. They, however, occurred from January to April.

Frog bones were found in the gut of one fish measuring 19 cm. in length.

In the light of all the food organisms ingested, it seems that adolescent and older fishes are mid and surface feeders. Fishes such as *B. stigma* and *E. danricus*, which are readily eaten by *O. punctatus*, are pelagic species and are likely to occur throughout the column zone, from surface to the bottom. The presence of insects such as *Corixa*, *Notonecta*, and dragon fly nymphs in the gut which are mainly surface dwellers seem to confirm the surface feeding habit. The other murrel *Ophicephalus striatus* has been previously reported as a bottom feeder (Das & Moitra 1956), which seems unlikely because its main food as suggested by these authors includes insects and fishes.

The greater occurrence of fish in the gut suggests that the larger fishes are mainly piscivorous. Insects and other food organisms are of secondary importance for the large-sized fishes as the fish measuring 22 cm. and above hardly contained anything else except fish. The occurrence of insects and other organisms was mostly in smaller fishes. The greater proportion of *B. stigma* in the food and its consistent occurrence throughout the year suggest that *O. punctatus* has a marked preference towards this fish.

(*b*) *Food of Immature Fishes*

Fishes ranging from 3.5 cm. to 9.9 cm. were kept in this category. The total number of guts examined of this size range was 438, of which 390 contained food. As the fish of this size range were only available from August to March, it became possible to make analysis of their guts only in these months. The percentage occurrence of various categories of food of the immature fish is shown in Table VI.

It is clear from the table that the food preferences of the immature fishes differ considerably from those of the older fishes. Some such organisms as Ephemeroptera nymphs, copepods, daphnids, and other crustaceans, which are never eaten by the older fishes, are included in the diet. Fig. 7(B) shows the percentage occurrence of the main categories of food in various months.

As can be seen from the figure, for this size group, fish does not form the major item of food. Of the total number of guts examined only 8.0% contained fish. This is in contrast to the previous size group where fish was found in 68.5% guts. Even in this size group, whenever fish was recorded in the gut it was in those specimens which were of relatively larger size. Evidently the smaller fishes are incapable of catching other fishes, but as they grow bigger they begin to hunt for them.

Insects (Diptera, Hemiptera, Odonata, Ephemeroptera, and Coleoptera) constitute the main bulk of food of this group. They occurred abundantly throughout the period of investigation. Dipterous insects

TABLE VI

PERCENTAGE OCCURRENCE OF VARIOUS CATEGORIES OF FOOD IN THE GUTS OF IMMATURE FISHES (*O. punctatus*)

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
No. of fish examined	6	37	45	27	14	11	..	..	..	..	77	101	57	32	16	3	8	4	..
No. of fish with food	6	34	41	23	13	10	..	..	..	..	71	86	50	29	14	3	7	4	..
Food & body wt. ratio	2.41	2.12	2.13	1.76	1.79	1.81	..	..	..	..	2.01	1.95	1.90	1.98	1.56	1.86	1.88	2.01	..
Barbus stigma	16.7	23.5	7.3	4.3	..	..	..	..	..	..	..	5.8	12.0	20.7	7.1	..	14.3	..	..
Esomus danricus	..	2.9	2.4	..	..	..	..	..	..	..	1.4	2.3	..	..	..	..	..	..	..
Diptera	..	20.6	68.3	47.8	61.5	50.0	..	..	..	..	8.4	4.6	10.0	44.8	57.1	100.0	71.4	100.0	..
Hemiptera	50.0	26.5	19.5	17.4	15.4	40.0	..	..	..	..	21.1	22.0	16.0	10.3	14.3	33.3	28.6	25.0	..
Odonata	..	11·8	31.7	26.1	38.5	20.0	..	..	..	..	..	..	2.0	20.7	28.6	33.3	14.3	25.0	..
Coleoptera	..	8.8	9.7	4.3	..	..	..	..	..	..	7.0	9.3	2.0	6.9	..	..	..	..	..
Ephemeroptera	16.7	8.8	4.9	..	..	10.0	..	..	..	..	7.0	3.5	8.0	3.4	7.1	..	14.3	..	..
Hymenoptera	..	..	..	..	..	..	..	..	..	..	1.4	..	..	..	..	..	..	..	
Digested insects	16.7	17.6	2.4	8.7	..	..	..	..	..	..	2.8	3.5	2.0	..	..	..	14.3	..	..
Copepods	16.7	5.9	14.6	39.1	23.1	10.0	..	..	..	..	81.7	70.9	68.0	44.8	14.3	..	14.3	..	..
Daphnids	..	2.9	14.6	21.7	23.1	10.0	..	..	..	..	62.0	44.2	40.0	34.5	14.3	..	14.3	..	..
Crustacean larvae	..	..	..	..	..	..	..	..	..	..	..	1.2	16.0	16.0	17.2	..	..	..	..
Rotifers	..	..	..	..	..	..	..	..	..	..	14.1	13.9	12.0	6.9	..	..	..	..	..
Gastropoda	..	..	7.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Algae	..	..	..	8.7	7.7	10.0	..	..	..	..	..	1.2	2.0	..	7.1	..	..	..	..
Higher aquatic plants	..	..	2.4	..	..	..	..	..	..	..	1.4	..	..	..	..	..	..	..	..

included chironomid larvae and pupae. They were rarely seen in the guts of large-sized fishes. Here they were present in nearly 50% guts. In January, February, and March practically all the guts had chironomid larvae and in some fishes as many as 100 larvae were recorded. Chironomid pupae were seldom seen in the guts and mosquito larvae were scarcely present. In this size group, water bugs (*Corixa*, *Notonecta*, and their nymphs) were relatively more abundant and so was the occurrence of dragonfly nymphs. These nymphs as they are eaten by the larger fishes measuring 7 cm. and above were more frequently seen during winter months. May-fly nymphs (Ephemeroptera) which were not found in older fishes were of common occurrence in this group. Similarly copepods (mostly cyclops) and daphnids were never recorded from the guts of older fishes. They were abundantly seen in the guts of smaller fishes particularly from August to October. Many guts of smaller fishes were full of cyclops and their number in one gut was more than 500.

Rotifers were recorded only from fishes measuring 4.5 cm. and below and were found from August to November. Crustacean larvae (nauplii) were found in the months of September, October, and November and constituted 2.4% of the total food.

Organisms of lesser importance were coleopterous insects and algae. One fish measuring 9.6 cm. contained a yellow wasp (Hymenoptera).

From the various categories of food eaten by this size range it appears that smaller fishes are also surface feeders. Excepting chironomid larvae which are bottom dwellers, most of the other organisms ingested live at or near the surface. Probably feeding on chironomid larvae occurs in shallow waters.

(*c*) *Food of the Larvae*

An analysis of the gut contents of 40 larvae has been given in an earlier communication (Qayyum & Qasim 1962). This indicated that the food of the young fishes consists of planktonic organisms such as cyclops, daphnids, rotifers, etc. This has been further confirmed by an analysis of the guts of 22 more larvae in the month of July. This has been given in Table VII.

TABLE VII

PERCENTAGE OCCURRENCE OF FOOD IN THE GUTS OF LARVAL FISHES (*O. punctatus*)

No. of fish examined	22
Size range	7 mm. to 10 mm.
Copepods	100.0 per cent.
Daphnids	13.6 per cent.
Crustacean larvae	31.8 per cent.
Invertebrate eggs	13.6 per cent.
Rotifers	22.7 per cent.

(*d*) *Seasonal Variation in the rate of feeding*

Seasonal variation in the rate of feeding was determined by the weight method previously used by Qasim (1957a, 1957b) and others. After

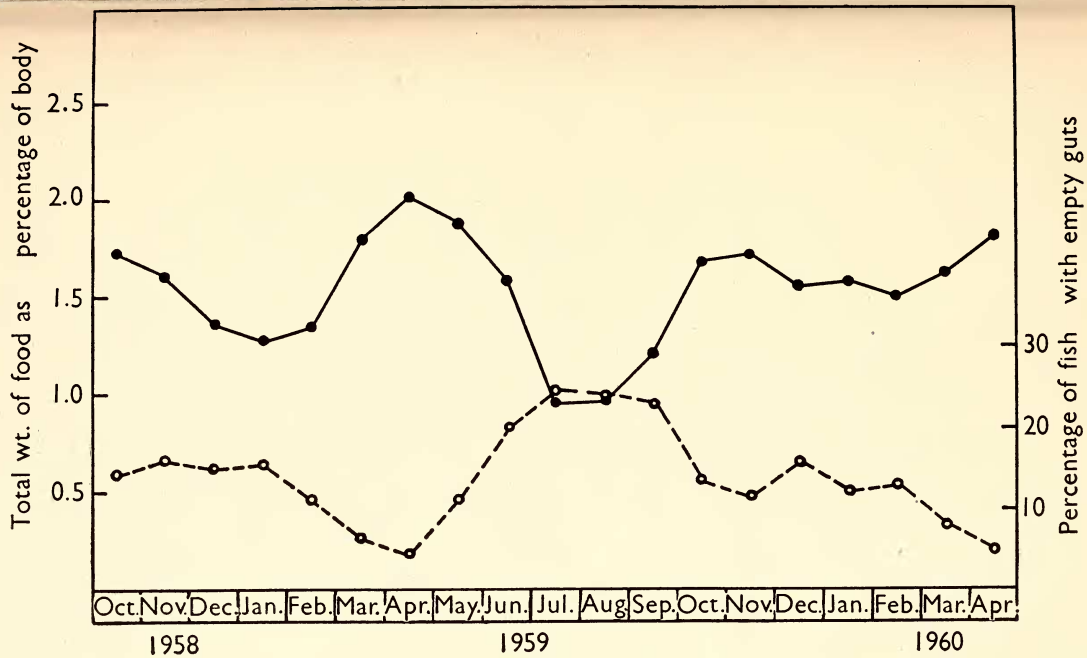

FIG. 8. Seasonal variation in the rate of feeding of *O. punctatus*

Total weight of food of adolescent and older fishes as percentage of body weight, continuous line. Percentage of empty guts, broken line

the qualitative analysis of food was over, the gut contents of all the fishes of a particular size range were mixed together, the excess of water was removed, and the total quantity of food was weighed accurately. This was expressed as the percentage of the total body weight of fish examined. A record of the empty guts was also maintained in each month.

The values obtained in various months have been illustrated in Fig. 8 together with the percentage of empty guts in each month. There were notable variations in the rate of feeding in different seasons. Two periods of intensive feeding were obtained in a year. The first was during the pre-monsoon months (March-June). Presumably a high rate of feeding during this period is required for the building up of gonads and the next phase, as it occurs after the spawning season (October and November), is utilised for the recovery of the fish from the spawning and for building up winter reserves. Feeding is minimal during the breeding season (July and August) when most of the fishes have ripe gonads. Again a cessation of feeding activity occurs during winter months (December-February) when there is a possible decline in the availability of food or perhaps the fish becomes less active in hunting its prey due to prevailing low temperature conditions.

The rate of feeding of smaller fishes (immature) shows a different picture. From the data given in Table VII it appears that in December and January there is a slight decrease in the rate of feeding while in other months there is hardly any variation in the quantity of food consumed.

(*e*) *Concluding Remarks on Food*

From the analysis of food of various size groups it can be concluded that the food of *O. punctatus* throughout its life is as follows : Newly hatched larvae feed on small planktonic organisms such as copepods (cyclops), rotifers, and crustacean larvae. As the larvae grow a little bigger they begin to eat other organisms also, such as daphnids and insect larvae. Small metamorphosed fishes continue to feed on planktonic crustaceans until they reach 5 cm. in length. However, with the increase in size there is a proportionate reduction of planktonic crustaceans until in small fishes measuring 6.5 cm. and above, these organisms become almost negligible in quantity. Such fishes change to larger organisms such as insects and their larvae. Medium-sized fishes measuring 6 cm. to 9 cm. have the main bulk of food made up of insects and other invertebrate organisms. Fishes measuring 9 cm. and more begin to feed on fishes, and finally in the largest-size groups fish becomes a major food item.

To sum up, it seems that *O. punctatus* remains a carnivorous fish throughout life, feeding mainly on invertebrate fauna. Its predation on other forage fishes is a feature acquired later in life.

(*To be continued*)